Winning in Time: Enabling Naturalistic Decision Making in Command and Control

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Network-Centric Warfare

Key US proponents of the Revolution in Military Affairs described future war as a system of systems in which dominant battlespace knowledge would enable a system of sensors and shooters to be connected for the purpose of engagement through an advanced, information technology-based command and control function (Fig 1). Through dominant battlespace knowledge, the command and control function would achieve efficiency levels which would greatly alter the nature of conflict – current time constants in the decision, action, feedback loop would be drastically shortened. The nature of weapons and platforms would change and the organization and training of forces would change.

Stuart Johnson and Martin Libicki, in their National Defense University publication Dominant Battlespace Knowledge, offer an analytical tool to understand the value of dominant battlespace knowledge in a network-centric force application concept (Fig 2).

Perfect command and control (C2) is achievable only with perfect information – dominant battlespace knowledge. Dominant battlespace knowledge essentially represents the command and control function's understanding of the situation as near-perfect. Although this level of understanding may be achievable in certain environments, its potential is challenged by the emerging nature of conflict – one described by Samuel Huntington as the Clash of Civilizations. Huntington sees future conflict as humanistic, driven by fault lines between cultures and economies. Conflict of this nature challenges the ability to achieve dominant battlespace knowledge. Furthermore, the centers of gravity in such a conflict are much more broadly distributed across a nation's economy, infrastructure, international relationships, internal divisions and armed forces.

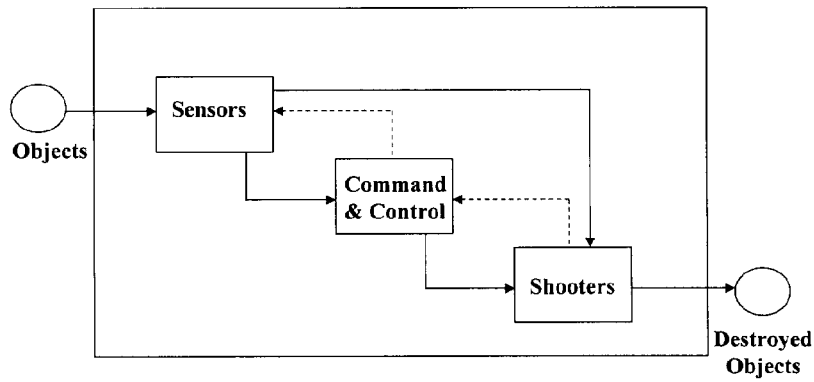

Figure 1: System of Systems Approach

Paper presented at the RTO HFM Symposium on "Usability of Information in Battle Management Operations", held in Oslo, Norway, 10-13 April 2000, and published in RTO MP-57.

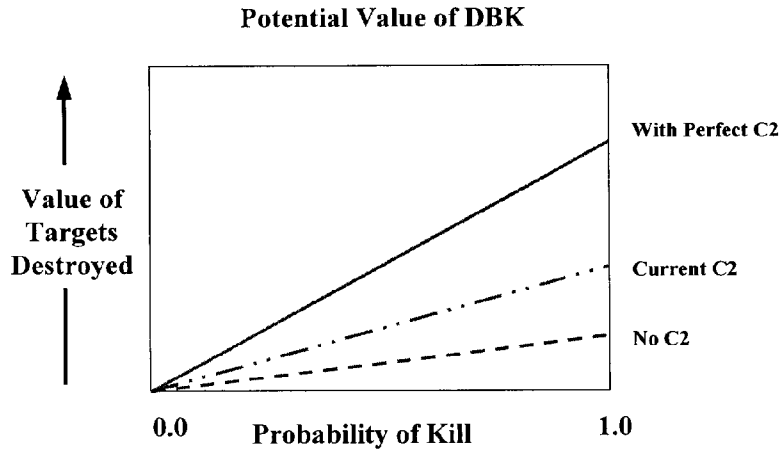

Figure 2: Dominant Battlespace Knowledge (DBK) in Command and Control (C2)

Changing Face of National Power

At the same time the nature of conflict is changing, the nature of national and Alliance power is changing. The information age creates the potential for a seamless system of power resources which spans a spectrum from the strategic use of information and information operations to the application of information-based strategic and tactical weapons systems. In the future, a multi-dimensional approach will emerge in which all elements of national power including economic instruments, political instruments, information instruments, and military missions are applied synergistically across an info-kinetic power spectrum (Fig 3).

This will have a significant impact on military actions at the operational level. No longer will the task force commander be purely concerned with the impact of his actions on the enemy's forces. Nor will the destruction of forces and the seizure of strategic resources be the singular determinant in changing enemy behavior. The task force commander will, to a larger degree than ever before, have to integrate actions and the actions of others into a continuous, coherent, multi-dimensional plan.

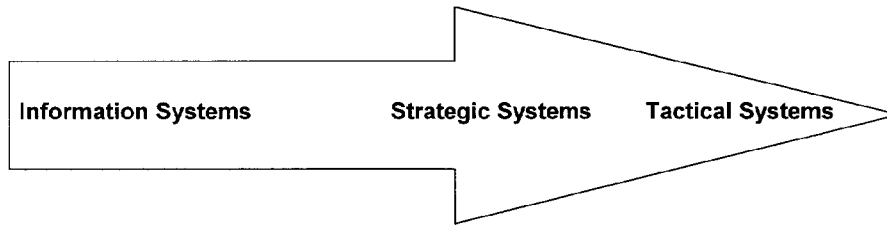

Figure 3: Info-Kinetic Power Spectrum

Complexity at the Operational Level

The operational decision environment will become non-linear with non-linearity defined as a condition in which a system disobeys principles of proportionality and additivity. Non-linear systems provide erratic or "chaotic" responses to inputs – cause and effect are difficult to track through a series of nodes in which forces interact. Achieving a sufficient level of understanding in these non-linear enviroments will require special tools and familiarity with complex decision techniques.

Decisions in Environments of Complexity

Study of decisions in complex scenarios reveals two fundamental styles -- an Analytic Style and a Naturalistic or Recognitive Style. The analytic style is characterized by a systematic data collection effort and a formal analysis and evaluation of various options. The naturalistic or recognitive style is characterized by an intuitive use of patterns leading to decision based on experience in like or similar situations (Van Riper and Hoffman, 1997). Experts in dynamic decision environments -- the master chess player, the NBA basketball player, the great general -- make decisions intuitively based on the comparison of current situation understanding to past situations and outcomes. These experts take advantage of the speed of the naturalistic or recognitive approach to act quickly – to outmaneuver their opponents by reducing the time to determine the action required. (Trotter, 1986)

System Evaluation

Understanding the complex causal chains in a non-linear system requires the use of one of a limited number of powerful system evaluation techniques. One such technique is Systems Dynamics (Inset 1). It was developed by an MIT professor, Jay Forrester. Forrester modeled webs of activity that

Systems Dynamics – A Snapshot

Prior to modeling a System of Alliance power, it is necessary to establish a fundamental understanding of the Systems Dynamics method. As inferred in the previous section, the Systems Dynamics approach to system evaluation is based on the principle of causal chains made up of paired variables that are related through physical or information flows. In the relationship, an independent variable acts upon the other variable, the dependent variable. Variables are paired in graphic form to show the direction of the influence and the polarity of the relationship. The key variables of interest in a Systems Dynamics model are called level variables. Levels are deteriorated or increased by rate variables. The relationship between level and rate variables is depicted by a solid line with an arrow head indicating the direction of influence and a plus or minus sign to indicate the polarity of the relationship. In a positive relationship, both variables move in the same direction. In a negative relationship the dependent variable moves opposite the direction of the independent variable.

Inherent in the evaluation of a Systems Dynamics model is the identification of feedback loops in which causal streams and the information relationship within those streams cause the system to exhibit characteristic behaviors. First and Second order positive feedback loops grow or decay exponentially once moved from an equilibrium state. First order negative feedback loops correct from a deviation to an equilibrium state. Second order negative feedback loops oscillate around an equilibrium value. Identifying feedback structures within a system or sector and understanding the behavior associated with structures present, will allow prediction of behaviors and the evaluation decisions which policy makers make in an effort to try to influence a system's behavior.(Drew, 1998). This description is not an all inclusive primer on Systems Dynamics. It is designed only to allow the reader to evaluate and appreciate the model of Alliance power which will be developed and explored in subsequent sections.

nset 1: Systems Dynamics Methodology for Depicting Causal Streams

were interrelated through shared information, shared physical resources, and interactive feedback loops. He demonstrated system characteristics between related variables and was able to develop causal chains that could be evaluated numerically or graphically to provide insight to complex and counterintuitive behavior. He did this for a world model, for commercial industries, and for government evaluation of policies. Forrester identified that systems are made up of basic feedback structures which have known behavioral characteristics. He demonstrated how the elements of system structure and behavior could be used to understand the behavior of large, multi-discipline, complex systems of interaction which he terms as metaproblems (Martin, 1996) (Drew, 1998).

System of Alliance Power

In order for military commanders to develop a systems view of national and Alliance power, we need a model that links together the various sectors of influence of the elements of power – economic policy, political policy, information policy, and deployment and application of military force.

Economic Sector

The economic sector, contained in the total power model, is represented by the relationship between Capital Investment, Capital, Industry Output, and Gross National Product (Fig 4). Note the positive feedback loop which is formed by this causal stream. This positive feedback loop, along with others identified in the successive sectors, are points of leverage for policy application.

Military Attrition Sector

A military attrition model is included in the integrated national security model. It represents a classic force-on-force battle in which force attrition is the determinant of victory. The attrition model is a second order positive feedback loop -- once influenced in the proper direction through an overwhelming initial attack, it can be pushed, especially if time is compressed, reducing the potential for restocking through domestic or foreign production. This positive feedback loop is central to evaluating force application policies.

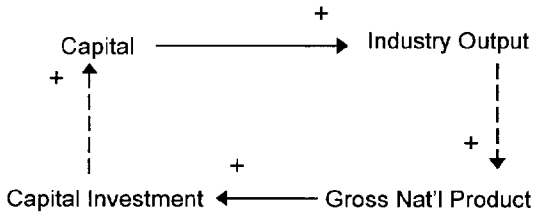

Figure 4: Positive Feedback Loop in the Economic Sector

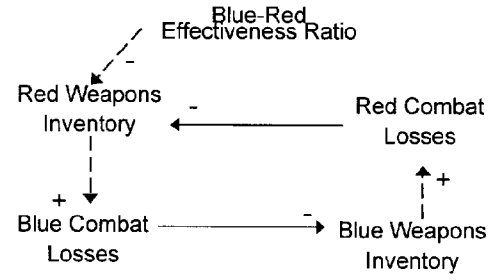

Figure 5: Positive Feedback Loop in the Military Attrition Sector

Political Power Attrition Sector

The political power attrition sector establishes the linkage between the power of the political leadership, the will of the people, and the perception of the international community (Fig 6). This sector model is in draft form and, is subject to refinement. In its current form, it is a conceptual tool to understand the causal relationships between the factors that work to provide a political power base.

This sector is central to understanding the effect of actions on the key measure of effectiveness – the willingness of the enemy to continue the conflict. Targeting the enemy's will is not new, it was part of the total strategy employed by the ancient Chinese warrior, Sun Tzu. What is new is that information combined with rapidly applied, precise force introduces an ability to shock the enemy and cause an early question in the minds of the people (Ullman and Wade, 1996). The keys in this sector are the linkages between the International Perception, Political Power of the Leadership, and the Will of the People.

Major influencing factors from the other two sectors are triggers to set in motion the two second order positive feedback loops contained in the Political Power Attrition Sector.

Information Multipliers

Imbedded in the model are Information Multipliers that are displayed as auxiliary variables at points of influence. These represent places where information operations can be used to magnify the effect of conventional actions. Learning to capitalize on these points of leverage will propel the system approach of power into the future giving the Alliance a whole new dimension from which to approach security issues.

Model of Alliance Power

A model of the system of national power is shown on the following page (Fig 7). It is displayed in a visual format – a causal diagram which allows the decision maker to see the interactions between and within the various components of an adversary's power base. Key points of leverage have been identified as positive feedback loops. These are not all inclusive, but they are the pressure points that can be used to resolve crisis at any point from identification up through force application.

A Model as a Tool for Leadership

The system level model illustrates the linking mechanisms between the previously described sectors. Understanding the system aspect requires visualization of the interactions between the various sectors of the model. Although a crude representation of the whole system, the model has immense value in demonstrating the system aspects of national and Alliance power. It serves as a tool to build a broad set of reference patterns that future leaders may use in complex decision arenas – visualization and patterns enable recognitive or naturalistic decision processes (Czerwinski, 1998).

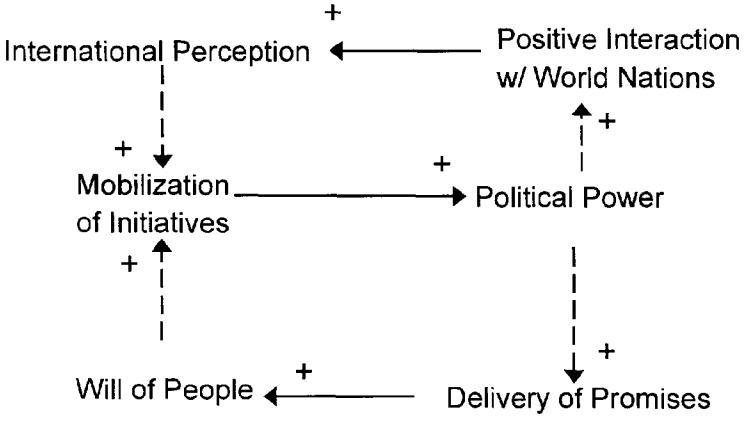

Figure 6: Positive Feedback Loops in the Political Power Sector

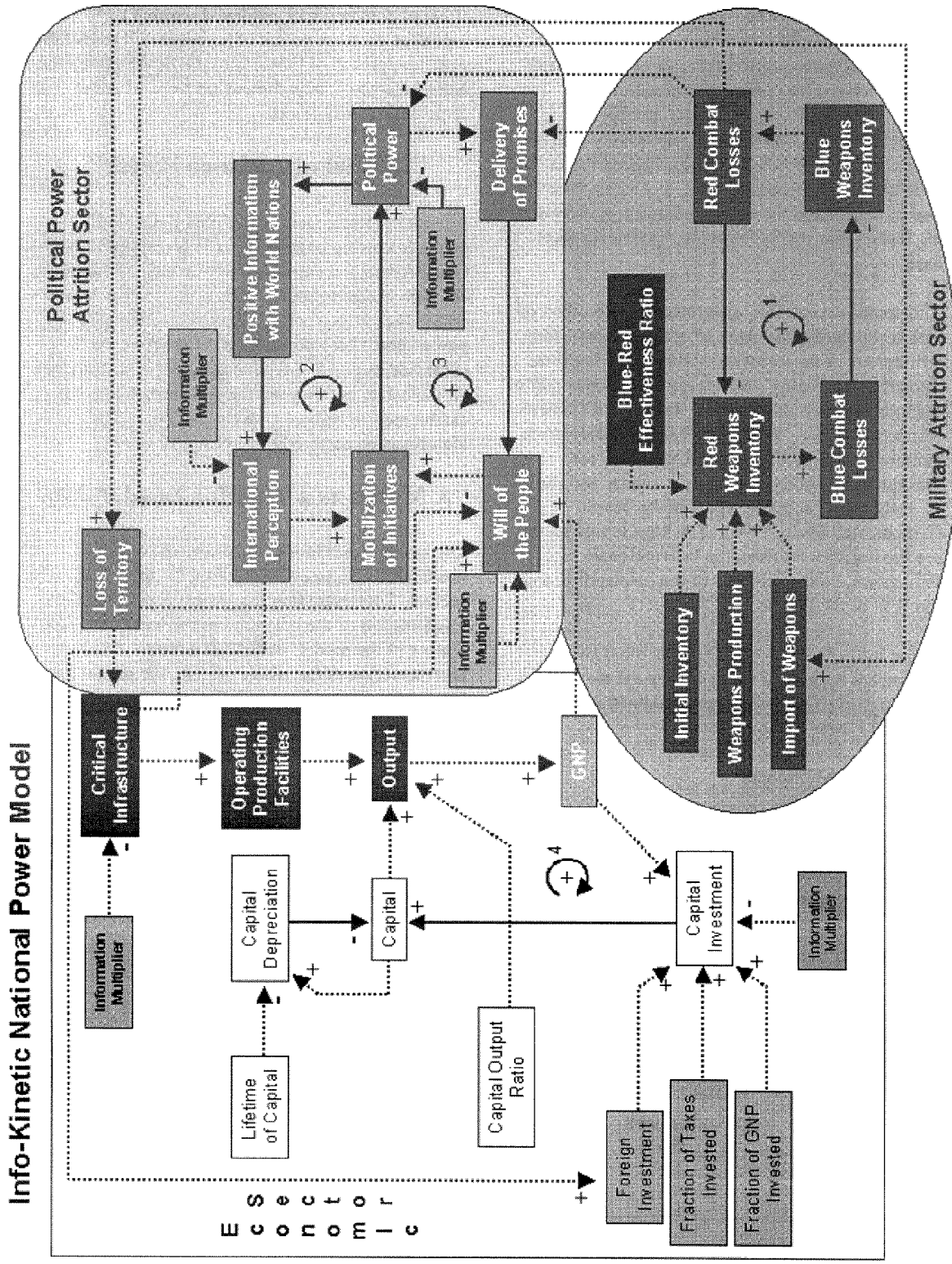

Figure 7: Causal Diagram of a System of National Power

At this point, we can update the chart proposed by Johnson and Libicki, revealing that we may be able to use visualization models as aids to learning -- enabling excursions into efficiency levels previously possible only through dominant battlespace knowledge (Fig 8) (Czerwinski, 1998).

Developing the Model

The first step in preparing the model is to employ a panel of experts from across the participating departments and agencies to more fully develop the definition of the model's variables and to validate the paired relationships between them. Once this step is complete, the model can become useful in the qualitative analysis of policy and strategy options.

The second step is to develop the mathematical relationships between the variables and to use the model to examine historical situations to calibrate the model for specific potential adversaries. This will make the model useful in quantitative terms. Once this step is complete, the model can be further incorporated into strategy experiments and gaming.

The third step is to use it as an evaluation tool in programming functions to test alternative procurement and application strategies. The results of various trials could be used to "what if" scenarios in order to provide leaders with an envisioned pathway towards a desired state.

Conclusion

The emerging complexity of the international security environment requires a broader, more integrated approach than was required in the Cold War era. This challenge can be met by an integrated application of the elements of national and Alliance power enhanced by an information technology network that enables collaborative formulation and execution of policies. This networked approach will create a more complex environment for leaders in each of the engagement elements. Decisions made in one arena will have direct intuitive and counterintuitive downstream effects that must be understood. Systems Dynamics offers a simple technique that can be used to map the system of national security measures enabling an understanding of the leveraging effects of networked, information based warfare. In the future, information will be as essential to warfare as any physical weapon system technology. With a valid model to serve as the propelling center of thought, information-based warfare will develop at rates that will provide a renewable competitive edge for the Alliance.

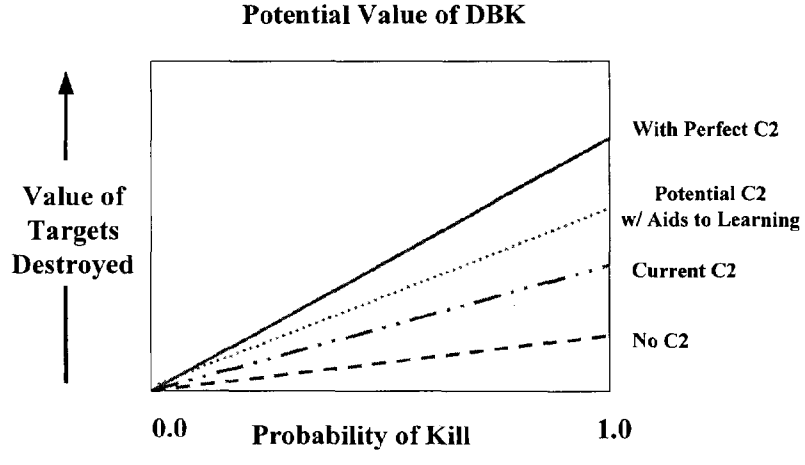

Figure 8: Leveraging Command and Control Through Aids to Learning

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